## FDM 14-10-1 General

*November 29, 2007*

### 1.1 Subgrade Improvement Impact on Pavement Thickness Design

The Bureau of Technical Services has implemented a statewide policy that incorporates the use of select material in the pavement design process. The philosophy is that the subgrade is improved through the use of select material. Therefore, the support value of the improved subgrade must be increased to include the influence of the select material.

Regardless of the material used to improve the subgrade, it is still considered subgrade and should be given no additional credit in the structural design process beyond what is stated in this procedure.

Note: The use of a sub-base layer is still acceptable.

### 1.2 Policy

#### 1.2.1 Flexible Pavements

When select material is placed according to the subgrade improvement initiative, the Design Group Index/Soil Support Value chart (Attachment 1.1) includes a second reference line that is to be used in order to establish a SSV of an improved subgrade. This second reference line is for DGI values from 8 to 20.

#### 1.2.2 Rigid Pavements

When select material is placed according to the subgrade improvement initiative, the modulus of subgrade reaction (k) should be increased to 375. This increase is based on the development of a composite k per the AASHTO '93 Guide for Design of Pavement Structures. One value has been established to cover all circumstances when a select material is used, due to the fact that the input values needed to determine a composite k are resilient modulus of the subgrade and elastic modulus of the subbase (select material).

**LIST OF ATTACHMENTS**

| | |
|---|---|
| Attachment 1.1 | Soil Support Value vs. Design Group Index |

## FDM 14-10-5 Hot-Mix Asphalt (HMA) Pavement Design

*December 22, 2011*

### 5.1 Basis of Design

#### 5.1.1 Traditional HMA Pavements

Thickness design is based on the structural number (SN) concept of the AASHTO Interim Guide [1]. The majority of the thickness of the pavement structure comes from the paving platform (refer to FDM 14-5-1).

#### 5.1.2 Deep-Strength or Perpetual HMA Pavements

To determine if either a deep-strength or perpetual HMA pavement design is required during the pavement type selection process, refer to FDM 14-15-1. The design is based on 20-year cumulative design ESALs. When these ESALs are anticipated to be less than 10 million, a deep-strength design is used. If these ESALs are projected to be 10 million or greater, a perpetual design is used.

Deep-strength HMA pavements are similar in design and composition to WisDOT's traditional HMA pavements; thickness design is based on the structural number. For these pavements, the majority of the structural number comes from the HMA pavement layers. The maximum SN given to the paving platform (either base aggregate dense or base aggregate open graded) is equivalent to that for a 6-inch aggregate base.

Perpetual HMA pavements are designed based on a maximum strain value at the bottom of the HMA pavement. Thickness design is determined using a mechanistic design procedure. These designs will be done by, or in conjunction with, WisDOT's central office (refer to Originator, FDM 14-1-1).

### 5.2 Roughness Index

The value of the roughness index for flexible pavement design is 2.5 PSI.

### 5.3 Traffic Loading

See FDM 14-1-5,"Traffic".

### 5.4 Soil Support

The soil support value for pavement design is to be determined and subsequently discussed in the soils report.

### 5.5 Design Equation

The WisPAVE design program uses the AASHTO '72 Asphalt Design Equation. Its use is based on Design Lane Total Life ESALs. That equation is presented here since there has been a need for designs with design lives less than 20 years (temporary roadways) and pavement evaluations based on accumulated ESALs.

$$\log(ESAL) = 9.36\log(SN+1) - 0.2 + \frac{\log\left(\frac{4.2 - P_t}{4.2 - 1.5}\right)}{0.4 + \frac{1094}{(SN+1)^{5.19}}} + \log\left(\frac{1}{R}\right) + 0.372(S - 3.0)$$

where:

ESAL = Total Life Flexible ESALs (see FDM 14-1-5)
SN = Structural Number
$P_t$ = Terminal Serviceability Index (PSI) (WisDOT uses 2.5*)
R = Regional Factor (WisDOT uses 3.0)
S = Soil Support Value (refer to Soils Report)

* WisDOT reports in IRI; however, this equation uses PSI.

### 5.6 HMA Mixture Layers

HMA pavement layers should be designed to the nearest ¼-inch. The plan thickness for lower and upper layers can be determined from standard spec 460.3.2.

By the Standard Specifications (standard spec 460.2.2.3), the normal nominal size mixture required for use is as follows (Lower Layer and Upper Layer are defined in standard spec 450.2.1):

- Lower pavement layer - 19.0 mm
- Upper pavement layer - 12.5 mm
- SMA pavement layer - 12.5 mm

Based on these nominal sizes and the minimum layer thickness from standard spec 460.3.2 the standard structure results in a 4.0-inch pavement. It is allowed to place a 12.5 mm nominal size mixture for the lower layer, which results in a 3.5-inch pavement. However, a change such as this requires a special provision stating that the lower layer would be a 12.5 mm nominal size mixture.

The use of a 9.5 mm nominal size mixture is also being allowed for the following applications:

- In a wedging or leveling layer,
- For bridge deck overlays,
- In urban situations to aid in matching the curb line and to provide a finer appearing mixture often desired in local paving.

The 9.5 mm nominal size mixture allows a minimum layer thickness of 1.5 inches to be used. In these applications, the 9.5 mm nominal size mixture may be used for both upper and lower layers, resulting in a 3.0-inch pavement.

### 5.7 Structural Layer Coefficients

The terms "structural layer coefficients," "layer coefficients," and "strength coefficients" are used interchangeably.

Attachment 5.1, Structural Layer Coefficients, shows strength coefficients for various materials normally used in pavement structures. These coefficients are not absolute but are consistent with minimum strength values that are expected from materials throughout the state. Each layer of an HMA pavement structure receives the loads from the layer(s) above, spreads them out, and distributes the loads to the layer(s) below. Therefore, the deeper a layer is in the pavement structure, the less load it must support. Due to this behavior, pavement structural layers are typically arranged in order of decreasing material strength (with those having the strongest layer coefficients being at the top). This concept should be used for all WisDOT pavement designs.

Since it is possible that the type of dense graded base (standard spec 305.1) that will be used on a project is not always known, the Pavement Design Engineer should use the lower (crushed gravel) structural layer coefficient. This assures that an under-designed pavement will not be built. If the source of aggregate is positively known, or if the design involves rehabilitation of an existing pavement structure with known materials, a different layer coefficient can be used.

### 5.7.1 Milled and Re-laid or Pulverized Hot-Mix Asphalt Pavement

This material can vary in both strength and stability. Typically, one to two inches of the existing base are pulverized along with the pavement, thereby producing a blend of pavement and base material. Therefore, when processing a thin HMA pavement (e.g., 3 inches), the net effect is essentially a base aggregate dense layer with a structural coefficient of either 0.14 or 0.10 depending on whether the material contains crushed stone or crushed gravel. If processing a thicker HMA pavement (e.g. 6 inches or greater) a structural coefficient as high as 0.25 can be used if the material contains crushed stone. Refer to FDM 14-25-20.4.2 for additional guidance regarding structural layer coefficients of pulverized material.

### 5.7.2 Rubblized Concrete Pavements

The recommended coefficient for rubblized concrete pavements ranges from 0.20 to 0.24. If the concrete pavement being rubblized is over a sound base and/or subbase, a coefficient of 0.24 could be used for the rubblized material.

### 5.7.3 Intact Concrete Pavements

The coefficient range for intact concrete pavements is 0.10 to 0.54, depending on the condition of the concrete pavement. For example, a coefficient of 0.54 could be typical of a new concrete pavement.

## 5.8 Subbase

Attachment 5.2, Relative Strength Coefficients for Granular Subbase, shows a chart that can be used as a guide for selecting the strength coefficient for granular subbase material, knowing the general gradation of the material available. The chart is based on tests conducted by the Bureau of Technical Services, Geotechnical Section.

When granular subbase is used as part of a pavement structure, the portion of strength it contributes to the total pavement structure shall be limited to a maximum of ten percent of the design SN, regardless of its strength coefficient or thickness used. The purpose of the ten percent limit is to ensure that adequate amounts of pavement and base are used in the pavement structure.

## 5.9 Staged Construction

For staged construction, individual lifts should be analyzed so no one layer is overstressed before the entire structure is completed.

## 5.10 PG Binder Selection Criteria

### 5.10.1 Upper Layers

1. Rural Projects: (for ≥ 4 million ESALs see High Traffic Volume)
    - New Base: PG58-28 (PG58-34 if north of STH 29)
    - Overlay: PG58-28
2. Urban Projects & Sections:(areas of increased turning, stopping, or parking movements; waysides, parking lots)
    - New Base: PG64-28 (PG64-34 if north of STH 29)
    - Overlay: PG64-22
3. Stop Condition Intersections:(e.g., two US highways with turning movements) (see also STSP Item 460.4200.S, HMA Pavement Intersections)
    - New Base: PG64-28
    - Overlay: PG64-22

4 High Traffic Volume: (≥ 4 million ESALs)
- Sustained Speed < 55 mph
    - (≥ 4 million ESALs: PG64-28 (PG64-34 if north of STH 29 & over new base)
    - (≥ 10 million ESALs: PG70-28

- Sustained Speed > 55 mph
    - (≥ 4 million ESALs: PG58-28 (PG58-34 if north of STH 29 & over new base)
    - (≥ 10 million ESALs: PG64-28 (PG64-34 if north of STH 29 & over new base)

5. Use of “P” Designated Binders: (PGxx-xxP)
    - For (≥ 5 million ESALs, substitute the equivalent “P” designated binder for the selected grade, if one is available as a bid item. The following “P” designated binders are available as bid items: PG58-34P, PG64-28P, PG64-34P, and PG 70-28P.

### 5.10.2 Lower Layers:

- PG58-28: normal
- PG64-22: if upper layer PG64-xx or higher

### 5.10.3 Notes:

1. All ESAL designations are 20-year design life values.
2. Use a maximum of three different PG grades per project. Limit to two if possible.
3. Switching the PG grade from that required in the contract is not allowed by standard spec 455.2.1. Only changes made to meet these guidelines should be considered and requires a contract change order.
4. Before use of any PG grades not conforming to these guidelines, or if you have any questions about these guidelines or their application, please contact:

    Thomas F. Brokaw,
    Materials Laboratory Unit Supervisor
    Materials Management Section
    DTSD, Bureau of Technical Services
    (608) 246-7934
    thomas.brokaw@dot.state.wi.us

## 5.11 Design Process

WisDOT uses the WisPave program to design pavements. See FDM 14-15-10 for instructions for obtaining this software.

## 5.12 Edge and End Joints

Attachment 5.3, Attachment 5.4, and Attachment 5.5 show edge and end joints that are appropriate for HMA pavement resurfacing projects. They may be used in estimating quantities of HMA materials as well as providing guidance in preparing special detail drawings for construction plans.

When special details for end joints of the overlap type (see Attachment 5.4) are included in a construction plan, the terminology used to identify this type of joint must clearly differentiate it from ordinary “construction type” butt joints that may also be included in the plan. Use of the notation “overlap joint, butted” will adequately serve this purpose.

Attachment 5.5 shows the notched wedge longitudinal joint, the standard joint to be used at HMA pavement centerlines and lane lines. However, a longitudinal butt joint should typically be used for single layer HMA overlays and for SMA pavements. The notched wedge longitudinal joint should be constructed by tapering the edges of the HMA pavement layers. The taper shall include a notch at the top of the layer and have a 12:1 slope for the remaining layer depth below the notch.

## 5.13 Tack Coats

Tack coats are used to help bond HMA overlays to existing HMA or concrete pavements. It is recommended that tack coat be applied between each layer of HMA pavement. Traffic should be kept from driving on tack areas until the overlying HMA surface has been placed. The rate of application is to be 0.025 gals/yd2.

## 5.14 General Application Guidelines

The following guidelines should be used when selecting and placing HMA pavements.

1. Plant-mixed asphaltic bases should not be used in lieu of binder courses in HMA pavement. There appears to be no economic advantage using asphaltic base for this purpose, since to obtain an equivalent structural strength requires the use of approximately one-third more material.
2. Since modern paving equipment can adequately handle minor profile and cross-section deviations, scratch courses should not be used. Major deviations should be corrected as indicated in the Standard

Specifications under "Correcting Sags and Depressions."

3. HMA resurfacing shall not be carried across bridge decks unless the surface is first protected by a waterproof barrier to reduce the deck's deterioration. An exception to this is when the deck surface is in poor condition and its replacement or major repair is planned within the next five to ten years. In this situation, resurfacing may be carried across the deck without special treatment.
4. When terminating HMA resurfacing at the ends of bridges, project termini, intersections, etc., a butt joint constructed by sawing or grinding the existing pavement is the preferred type of joint.
5. The slow moving or standing loads in intersections, climbing lanes, truck weigh stations, and other slow-speed areas subject the pavement to higher stress conditions. The key to constructing a successful pavement is recognizing that these areas may need to be treated differently. Consider using STSP Item 460.4200.S, HMA Pavment Intersections, in these areas.

### 5.14.1 SMA Usage and Application Guidelines

- Use only as a surface layer (one or multi-layer system)
- Consider use when traffic is greater than 2 million 20-year design ESALs
- Consider use when lower maintenance is beneficial (high-traffic areas)
- Use in other applications when determined to be economically feasible

### 5.15 References

[1] AASHTO Interim Guide for the Design of Pavement Structures, 1972, Chapter III Revised, 1981

**LIST OF ATTACHMENTS**

| | |
|---|---|
| Attachment 5.1 | Structural Layer Coefficients |
| Attachment 5.2 | Relative Strength Coefficients for Granular Subbase |
| Attachment 5.3 | Edge Joints |
| Attachment 5.4 | End Joints |
| Attachment 5.5 | Longitudinal Joints |

## FDM 14-10-10 Concrete Pavement Design

*December 22, 2011*

### 10.1 Standard Pavement Type

WisDOT policy establishes jointed plain concrete pavement with dowels as the standard type of concrete pavement to be used on highways in Wisconsin. Details for this type of concrete pavement are shown in SDD 13C11 and SDD 13C13.

### 10.2 Traffic Loading

See FDM 14-1-5, "Traffic."

### 10.3 Modulus of Subgrade Reaction

Westergaard's Modulus of Subgrade Reaction (k) is used in this procedure to express the supporting capability of the subgrade soil. It represents the load in pounds per square inch on a loaded area, divided by the deflection in inches of that loaded area, psi/inch.

The "k" value is best estimated on the basis of previous experience or by correlation with other tests. The "k" value to be used for design purposes is to be determined and reported in the soils report.

### 10.4 Design Equation

WisDOT uses the WisPAVE program to design concrete pavements. See FDM 14-15-10 for instructions on how to obtain this software. WisPAVE uses the AASHTO 1972 Portland Cement Concrete design equation [1] as its theoretical basis for concrete pavement thickness design.

### 10.5 Design Thickness

Design concrete pavements to the nearest 1/2 inch. If WisPave calculates a concrete slab thickness less than six inches, use a 6-inch thickness for undoweled concrete pavements and a 7-inch thickness for doweled concrete pavements in the LCCA.

$$\log(ESAL) = 7.35\log(D+1) - 0.06 + \frac{\log\left(\frac{4.5 - P_t}{4.5 - 1.5}\right)}{1 + \frac{1.62x\,10^7}{(D+1)^{8.46}}} + (4.22 - 0.32\,P_t)\log\left[\left(\frac{f_t}{690}\right)\frac{D^{0.75} - 1.132}{D^{0.75} - \frac{18.42}{\left(\frac{E}{k}\right)^{0.25}}}\right]$$

where: ESAL = Total Life Rigid ESAL's (see FDM 14-1-5)

D = Concrete Slab Thickness (inches)

$P_t$ = Terminal Serviceability Index (WisDOT uses 2.5)

$f_t$ = Working Stress of Concrete (490 psi)

E = Modulus of Elasticity of Concrete (4,200,000 psi)

k = Modulus of Subgrade Reaction (psi) (refer to Soils Report)

## 10.6 Joints

Concrete pavement jointing details are shown in SDD 13C18. Use SPV.0105.XX, *Concrete Pavement Joint Layout* (located at http://roadwaystandards.dot.wi.gov/standards/qmp/jointlayout.pdf) when using this SDD.

### 10.6.1 Transverse Contraction Joints

#### 10.6.1.1 Spacing

The spacing of transverse contraction joints for rural WisDOT concrete pavements is uniform at 15 feet.

For urban pavements the spacings are as follows:

- 12 feet for pavement thicknesses of 6 and 6-1/2 inches
- 14 feet for pavement thicknesses of 7 and 7-1/2 inches
- 15 feet for pavement thicknesses of 8 inches or greater

#### 10.6.1.2 Orientation

Transverse contraction joints will be constructed normal (90º) to the centerline.

### 10.6.2 Longitudinal Joints

Two types of longitudinal joints are used in concrete pavement--construction and sawed. Construction type longitudinal joints are used in the following situations:

1. For lane-at-a-time construction
2. Along ramp tapers
3. Along concrete shoulders and curb and gutter (when poured separately)
4. Along lanes added to existing pavement

Tie bars are typically used across these joints. In the fourth case, when adding lanes to existing pavement, holes are drilled into the longitudinal face of the existing slab. Tie bars are then driven into the holes prior to pouring the added lane.

Sawed-type longitudinal joints are used in the following situations:

1. Along the center line or between lanes
2. Along concrete shoulders (when poured with the pavement)

Tie bars are used across this type of longitudinal joint. For tie bar spacing, refer to SDD 13C1 titled, “Concrete Pavement Longitudinal Joints and Pavement Ties.”

Pavements greater than 15 feet in width should have a longitudinal joint installed so that the maximum pavement width does not exceed 15 feet. Different situations will dictate the location of the longitudinal joint.

## 10.7 Sealing

It is department policy to not seal or fill longitudinal or transverse joints in concrete pavements. Joints in new concrete pavements will be cut as narrow as possible (on the order of 1/8 inch in width). No joint sealants, sealant systems, or fillers will be utilized on any type of concrete pavements except for research purposes.

This policy applies to new construction of all rural and urban highways, all functional classes of highways, all types of concrete pavement, all base course structures, and all soil types. The only exception to this would be local projects (local ownership and maintenance responsibilities) where a local government has expressed a preference for filling or sealing. In this case, a hot-pour asphalt, without over-banding, is recommended as the sealant material and it would be at the expense of the local unit of government.

### 10.8 Construction Joints

All transverse construction joints are of the butt type and are tied with bar steel reinforcement as shown on the standard detail drawing for the particular type of concrete pavement being constructed.

On concrete pavement projects with auxiliary lanes the placement of the longitudinal construction joint is important for traffic operations. When the total length of the auxiliary lane, including taper and longitudinal section, exceeds 800 feet the construction joint for concrete pavement shall be located at lane width. The designer should prepare a detail drawing to direct the contractor to “box-out” or otherwise construct the pavement showing the proper lane width, which should also be the construction joint location. Therefore, the construction joint shall be placed at the location of the proposed lane pavement marking.

### 10.9 Tining

When the design speed of a concrete highway is 40 mph or greater, the surface shall receive a tined finish as described in CMM 4-18 "Texturing and Tining,".

When tining is required, add a note to the appropriate typical section to indicate which sections of concrete pavement are to be tined.

### 10.10 References

[1] AASHTO Interim Guide for Design of Pavement Structures, 1972, Chapter III Revised, 1981

## FDM 14-10-15 Bridge Approach Pavements — November 17, 2010

### 15.1 Pavement Type

Bridge approach pavements represent a special situation. The choice of pavement type for bridge approaches shall be based on the following. Guidance on the use of a paving notch is provided in Bridge Manual Standard Drawing 18.1.

1. Reinforced concrete approach pavements shall be used on all roads carrying current traffic volumes in excess of 3500 AADT and on all bridges having skews in excess of 20 degrees.
2. Plain concrete approach pavements shall be used for bridge sites having embankments of stable, granular materials on roads carrying current traffic volumes less than 3500 AADT, except for bridges having skews greater than 20 degrees.
3. Asphaltic concrete approach pavement shall be used only on roads carrying traffic volumes less than 3500 AADT and on bridges where embankment stability is uncertain.
4. When concrete approach pavements are called for, the adjacent shoulder shall also be paved with concrete (full width) from the structure to at least the first transverse joint in the approach slab.

Exceptions to the above criteria may be made at the request of the maintaining authority.

## FDM 14-10-20 Highway Ramp Design — November 29, 2007

### 20.1 Pavement Type and Thickness

Interchange ramp pavements present a special situation. The choice of pavement type and pavement thickness should be based upon the following general guidelines.

1. For construction reasons, the pavement within the mainline taper and gore area should be constructed of the same pavement type and thickness as the mainline pavement. The mainline pavement can end, and the ramp pavement structure can begin, at a location where a uniform ramp width begins.
2. The ramp pavement design should be performed independent of the mainline pavement based upon the traffic projections for the individual ramps and with the following considerations:
   - Typically, for cloverleaf or diamond interchanges, all ramps are built according to a single pavement type and structure design. This should be based on the ramp that needs the strongest pavement.
   - Free-flow interchange ramps are usually of sufficient length and widths such that their pavement

design and selection should be based upon their own individual traffic projections.

3. Sufficient attention must be paid to maintaining pavement drainage through the interchange tapers, gores and ramps. See FDM 14-5-5 for more details.
4. A LCCA is not required for ramp designs.

## FDM 14-10-25 Paved Shoulders

*November 17, 2010*

### 25.1 Policy

FDM 11-15-1 contains WisDOT's shoulder paving policy and other guidance on the geometric design of shoulders.

### 25.2 Thickness Design

Paved shoulders must be structurally designed to withstand wheel loadings from encroaching truck traffic and should be based on usual design considerations appropriate for each situation. When using the AASHTO Interim Guide procedure to determine shoulder thickness, the number of ESALs per day used for design purposes should be a minimum of 2.5 percent of the value used for the mainline pavement.

Another consideration in determining shoulder thickness is the manner in which the paved shoulder will be constructed. In most cases it is more cost effective to allow contractors to pave the shoulder in conjunction with the driving lane (e.g., a 15-foot wide pass for a 12-foot lane and 3-foot shoulder). If this option is chosen for concrete pavements, a longitudinal joint is not required between the driving lane and the shoulder when their combined widths are 15 feet or less.

For HMA shoulders, the standard minimum thickness is 3½ inches. If the need for a greater thickness is identified, such as the shoulders being used to carry traffic for an extended period of time, use the same thickness design procedures that are used for the mainline.

HMA shoulders can be placed in either one layer or two layers. Situations that may benefit from placing HMA shoulders in one layer include:

- For shoulders paved separate from the mainline, it may be more economical to place in one layer due to a reduction of paving operations
- Increased performance of shoulders when paved over areas of questionable/variable support
- Increased performance of shoulders when they will be subjected to traffic soon after construction

Careful attention should be given to minimum/maximum layer thicknesses as related to size of aggregate in the mix (standard spec 460.3.2) and to the number of layers to be placed, as opposed to a minimum thickness based strictly on traffic loading and support values.

For concrete shoulders the standard minimum thickness is 6 inches.

### 25.3 Type Selection

The design and selection of the pavement type for paved shoulders should be discussed and documented in the pavement structure design report (see FDM 14-15-1).

A cement factor of at least 5.25 sacks per cubic yard is required for concrete shoulders. However, when shoulders are paved integrally with the mainline pavement, the cement factor must be that of the driving lane.

## FDM 14-10-30 Overlay Design

*November 18, 2009*

### 30.1 General

Once a pavement is judged to have deteriorated beyond the point where it is practical to continue routine maintenance activities, an overlay, either with or without the option of recycling, becomes the next logical step short of complete reconstruction.

Overlays are placed on pavements to improve their structural strength, riding quality, skid resistance, or a combination of these. Because of the different reasons for which an overlay may be required, as well as the diversity of the types and condition of pavements to be overlaid, the determination of overlay thicknesses (either flexible or rigid) has been, and to a large extent still is, empirical.

### 30.2 Methods of Design

The experience and observation of the designer (empirical method) are the main ingredients used to determine the need of resurfacing, with what, and how much. Basically, if the problem is just surface deterioration, a surface treatment or minimum resurfacing thickness would be called for. Severe problems such as areas with complete base failures require more substantial correction.

Chapter IV of the AASHTO "Interim Guide for Design of Pavement Structure, 1972, contains several analytic overlay design procedures that can be used to verify alternate choices as well as provide aid where questions exist concerning the structural capacity of pavements to be overlaid. One of these procedures (the Asphalt Institute Method) has been modified for use in Wisconsin and has previously been made available for use by the districts.

## FDM 14-10-35 Intersections

*June 23, 2011*

### 35.1 General

The term intersections, as used in this procedure, will apply to both traditional intersections (with cross traffic) and roundabouts.

Chapter 11, Sections 25 and 26 contain WisDOT's policy and other guidance on the geometric design of intersections.

### 35.2 Pavement Type Selection

Intersection pavements can be constructed of deep strength Hot Mix Asphalt (HMA), perpetual HMA, traditional HMA, or concrete. A Life-Cycle Cost Analysis (LCCA) is not required for pavement type selection.

Some of the factors that should be considered when selecting pavement types for intersections include:

- Adjacent pavement type
- Future or existing developments that impact traffic
- Traffic loadings of certain quadrants
- Condition and age of existing pavement - potential rehabilitation type
- Potential future expansion of intersection
- Continuity of maintenance
- Multiple utilities

The design and selection of the pavement type should be addressed in the pavement design report (see FDM 14-15-1).

### 35.3 Pavement Design

A separate structural design is not typically prepared for non-critical or low volume intersections. However, in situations where a separate design is to be prepared, the highest leg AADT should be used for the pavement thickness design, unless traffic information of specific turning movements is available, in which case that may be used instead.

Pavements at critical or high volume intersections present a special situation. The intersection pavement design should be performed independent of the mainline pavement based upon the traffic projections for the individual intersection and with the following considerations:

- Length of mainline
- Distance between intersections
- Relative difference in pavement thickness

Turning movements within intersections could increase traffic loadings in certain quadrants. To ensure adequate pavement thickness, consider applying a 1.5 multiplier to the highest leg AADT for the pavement thickness design if detailed traffic information is not available. If information of special turning movements is available, that may be used instead.

#### 35.3.1 Lane Distribution Factor

For lane distribution factors, refer to FDM 14-1-5.

#### 35.3.2 HMA Intersections

To avoid rutting and/or shoving due to the stresses applied by vehicles at high traffic intersections with stop conditions along with a high percentage of turning movements, HMA intersections (including roundabouts) with these conditions should be constructed with an HMA mixture using the guidelines established in STSP 460-030, HMA Pavement Intersections, Item 460.4200.S. to ensure good pavement performance. Analysis has shown that the intersection mixture is only required in the upper layer of the pavement structure. However, if an extended PG grade binder is required, there may be an economic advantage in utilizing a full tanker load of the binder. A typical tanker holds approximately 22 tons of binder, which will produce about 420 tons of HMA mixture. Any extra tonnage may be utilized by paving multiple layers in the intersection, by extending the intersection paving limits, or by paving another intersection.

In traditional intersections, the designer should use judgment in determining how far to extend the intersection mixture. In roundabouts, the enhanced mixture should extend to the pavement alongside the splitter islands (see FDM 11-26-1). In cases where the splitter islands are long, the designer's best judgment should be used in determining how far to extend the intersection mixture.

### 35.3.3 Concrete Intersection Jointing

Concrete pavement jointing details are shown in SDD 13C18. Use SPV.0105.XX, *Concrete Pavement Joint Layout* (located at http://roadwaystandards.dot.wi.gov/standards/qmp/jointlayout.pdf) when using this SDD. Dowel bar size and transverse joint spacing should be in accordance with SDD 13C11 and SDD 13C13, and SDD 13C18.

#### 35.3.3.1 Traditional Intersections

Joint layouts for traditional concrete intersections should be developed using the fundamentals provided in the American Concrete Pavement Association (ACPA) publication titled, "Intersection Joint Layout." Copies of this publication can be obtained from the Wisconsin Concrete Pavement Association (WCPA) or ACPA.

#### 35.3.3.2 Roundabouts

Two joint layout methods are acceptable for concrete roundabouts: the "Isolated Circle" method and the "Pinwheel" method (see SDD 13C18-1e). The "pave-through" method is not allowed, so as to avoid a driver's misperception of right-of-way entering into or traveling within a roundabout. A general note should be included in the plans specifying WisDOT's acceptable joint layout methods. Once the method is determined, the joint layout plan should be designed according to SDD 13C18-1e and the recommendations provided in ACPA's *Concrete Pavement Research & Technology (R&T) Update* titled "Concrete Roundabouts." Copies of this publication can also be obtained from WCPA or ACPA. The "Pinwheel" method is not referenced in this publication, but an example is shown in SDD 13C18-1e.

The joint layout may be influenced by the pavement cross-slope. Align the crown line with the longitudinal joint if possible.

When utilizing either jointing method for concrete roundabouts, the contractor should consider maximizing the amount of concrete that can be placed using a concrete paving machine to reduce labor-intensive handwork. To achieve this, the designer should maximize the use of uniform lane widths through the roundabout and at the approach legs whenever possible.

## 35.4 Roundabout Design Features

The central island should not appear as a traveling surface to drivers, therefore it should not be paved.

To minimize future maintenance disruptions to the roundabout, utility structures (e.g. manholes, valve boxes) should not be located in the circulatory roadway if possible.

SDD 13C18-1e shows the two acceptable joint layout methods for concrete roundabouts along with the roundabout elements that are tied and/or doweled.

### 35.4.1 Truck Aprons

Truck aprons should be 8 inches thick and constructed with concrete. The concrete should be integrally dyed or colored in a reddish tone so that the truck apron is recognizably different than the circulatory roadway. Bid items 405.0100 Coloring Concrete Red and 416.0508 Concrete Roundabout Truck Apron 8-inch are available for use on truck aprons. A red concrete comparison sample is available at each region office. Surface stamps or jointed chevrons are not recommended.

The truck apron should be jointed, but the transverse joints should not be doweled.

### 35.4.2 Curb, and Curb and Gutter

#### 35.4.2.1 Inside Curb

The inside curb around the central island should be tied to the truck apron.

#### 35.4.2.2 Mountable Curb and Gutter

The mountable curb and gutter between the truck apron and the circulatory roadway should have a gutter thickness of 8 inches regardless of the circulatory roadway pavement type or pavement thickness.

If the circulatory roadway is concrete, the mountable curb and gutter should be tied to the roadway, but not to the truck apron. Expansion joint filler should be used between the truck apron and the mountable curb and gutter.

If the circulatory roadway is HMA, then the truck apron should be tied to the mountable curb and gutter.